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Dated 21 July 2004

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03OCT03 E841817-1 D02888
P01/7700 0.00-0323146.1

Request for grant of a patent

(See the notes on the back of this form. You can also get an explanatory leaflet from the Patent Office to help you fill in this form)

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1.	Your reference	XLT 95
2.	Patent application number *(The Patent Office will fill in this part)*	0323146.1
3.	Full name, address and postcode of the or of each applicant *(underline all surnames)*	Phil Head Gibbs House Kennel Ride Ascot Berks SL5 7NT
	Patents ADP number *(if you know it)*	7920812001
	If the applicant is a corporate body, give the country/state of its incorporation	
4.	Title of the invention	Methods of deploying and powering an electrically driven device in a well
5.	Name of your agent *(if you have one)* "Address for service" in the United Kingdom to which all correspondence should be sent (including the postcode)	Hillgate Patent Services No. 6 Aztec Row Berners Road Islington London N1 0PW
	Patents ADP number *(if you know it)*	5953112002

6. If you are declaring priority from one or more earlier patent applications, give the country and the date of filing of the or of each of these earlier applications and *(if you know it)* the or each application number

Country	Priority application number *(if you know it)*	Date of filing *(day / month / year)*

7. If this application is divided or otherwise derived from an earlier UK application, give the number and the filing date of the earlier application

Number of earlier application	Date of filing *(day / month / year)*

8. Is a statement of inventorship and of right to grant of a patent required in support of this request? *(Answer 'Yes' if:*
a) any applicant named in part 3 is not an inventor, or
b) there is an inventor who is not named as an applicant, or
c) any named applicant is a corporate body.
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No

9. Accompanying documents: A patent application must include a description of the invention. Not counting duplicates, please enter the number of pages of each item accompanying this form:

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Continuation sheets of this form	–
Description	14
Claim(s)	–
Abstract	–
Drawing(s)	10+10

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10. If you are also filing any of the following, state how many against each item.

Priority documents	–
Translations of priority documents	–
Statement of inventorship and right to grant of a patent (Patents Form 7/77)	–
Request for a preliminary examination and search (Patents Form 9/77)	–
Request for a substantive examination (Patents Form 10/77)	–
Any other documents (please specify)	–

11. I/We request the grant of a patent on the basis of this application.

Signature(s) Fillgate Patent Services Date 1/10/03

12. Name, daytime telephone number and e-mail address, if any, of person to contact in the United Kingdom PAUL HARMAN 020 7704 9997

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Notes

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f) Part 7 should only be completed when a divisional application is being made under section 15(4), or when an application is being made under section 8(3), 12(6) or 37(4) following an entitlement dispute. By completing part 7 you are requesting that this application takes the same filing date as an earlier UK application. If you want the new application to have the same priority date(s) as the earlier UK application, you should also complete part 6 with the priority details.

METHOD OF DEPLOYING AND POWERING AN ELECTRICALLY DRIVEN DEVICE IN A WELL

FIELD OF THE INVENTION

This invention relates to a method of deploying an electrical submersible powered fluid transducer system, such as a gas compressor or an electrical submersible pump, generally known as an ESP, in an oil and/or gas production well.

BACKGROUND OF THE INVENTION

The disposing in wells of electrical submersible systems has been done for many years using jointed tubular conduits with an electrical motor, and a fluid transducer connected to the bottom of the jointed tubing. Consecutive joints of tubular conduits are connected and lowered into a well with the assistance of a rig mast and hoisting equipment, whilst unspooling and connecting to the outer diameter of the tubing a continuous length of electrical power transmission cable. This method of disposing the electrical submersible fluid transducer system is well know to those familiar with the art of producing non-eruptive sources of oil and gas from the subterranean environment. The retrieval of these electrical submersible fluid transducer systems is also commonly accomplished by pulling the jointed tubing out of the well simultaneously with the electrical submersible motor and fluid transducer system and the electrical power transmission cable.

The following prior art references are believed to be pertinent to the invention claimed in the present application: U.S. Pat. Nos. 3,939,705; 4,105,279; 4,494,602; 4,589,717; 5,180,140; 5,746,582 and 5871,051; International patent application No. WO98122692 and European patent specifications Nos. 470576 and 745176. U.S. Pat. Nos. 3,835,929, 5,180,140 and 5,191,173 teach the art of deploying and retrieving an electrical submersible system in oil wells using coiled or continuous tubing. These coiled tubing disposal methods often use large coiled tubing spool diameters owing to the radius of curvature possible of the continuous tubing. Hence the surface spooling devices that these systems require to inject and retrieve the continuous tubing are cumbersome, and require special surface and subterranean equipment for deployment and intervention. These methods all require the retrieval of the power cable with the continuous tubing for replacement of the equipment. Other previous art disclosed in the literature teaches the disposal and retrieval of the subterranean electrical fluid transducer system with wireline or wire rope as structural support for simultaneously disposing the electrical power transmission cable with the system. Hence these wireline methods and apparatus involve the use of large and unique surface intervention equipment to handle the weight and spool used for the electrical power cable and the wire rope, to be run simultaneously with the power cable in the well. These methods teach the retrieval of the electrical submersible power transmission cable with the submersible electrical motor. U.S. Pat. No. 5,746,582 discloses the retrieval of a submersible pumps whilst leaving an electrical motor and cable in a

well. Hence the method of U.S. Pat. No. 5,746,582 teaches the retrieval and deployment of the mechanically portion of an electrical submersible fluid transmission system whilst leaving the electrical motor and other component parts of the electrical submersible system disposed in the disposal of the electrical motor separately from the electrical

Power transmission cable. In the case of artificially lifted wells powered with electrical submersible motor systems, the current art is to dispose the required transducer assembly, for example a pump or compressor assembly, with an electrical motor and electrical power cable simultaneously into the well with a supporting member. This supporting member is jointed tubing from a surface rig, a coiled tubing unit with continues tubing or braided cable. The tubing or a braided cable is required as the electrical power cable is not able to support it's own weight in the well and hence must be connected and disposed in the well with a structural member for support. In the case of jointed pipe deployed from a rig, the power cable is attached to the electrical motor on surface, and the cable is attached to the tubing as the electrical motor, transducer, and tubing are disposed into the well casing or tubing. The attachment of the cable to the tube is done by the use of steel bands, cast clamps, and other methods known to those familiar with the oil and gas business. In other methods, the power cable is placed inside of continuous tubing or attached to the outside of continuous tubing with bands as taught by U.S. Pat. No. 5,191,173. This continuous tubing is often referred to in the industry as coiled tubing. U.S. Pat. No. 3,835,929 teaches the use of the continuous

tubing with the electrical power transmission cable inside of the tube. In all cases where electrical submersible fluid transducers systems are disposed and retrieved from wells the electric motor and electrical power transmission cable are deployed or retrieved simultaneously.

SUMMARY OF THE INVENTION

The method according to the invention comprises: connecting an electrical power cable to a first part of a wet mateable electrical power connector which is secured to a lower region of a production tubing; lowering the production tubing and the electrical power cable into the well; lowering through the production tubing an electrically driven downhole fluid transducer system which is equipped with a second part of a wet mateable electrical power connector; releasably latching the transducer system to the production tubing such that the two parts of the wet mateable power connector face each other. Lowering of the electrical submersible fluid transducer system may be achieved by any number of means, the most practical being a slickline or wireline conveyed system. If the device is in a deviated well then an electrically powered tractor could be used to convey it along the deviated section.

In addition, it is extremely important to maximize the internal diameter of the tubing to allow the largest sized motor and pump to be conveyed internally. Consequently, a novel packer arrangement is ideally employed which accommodates electrical feed throughs, and which is mechanical expanded using a mechanical roller system. This

eliminates all the complicated components of a traditional packer device while achieving all the required functions of a packer device. i.e. a pressure bulk head and tubing anchoring means. Finally to remove the expanded packer, an internal support may be lowered and installed, which traverses the expanded section. A suitable acid may then be pumped into the tubing which dissolves the expanded section, allowing the quick and simple recovery of the tubing.

It is well known to those familiar with electrical submersible power cable that the action of removing the cable from the well can result in damage to the electrical power transmission cable, in a variety of ways. The damage inflicted on the electrical power cable can be due to bending stresses imposed on the cable during the disposal and retrieval. The conventional electrical power cable insulation, wrapping, and shields can develop stress cracks from the spooling of the cable over sheaves and spools devices used to deploy the cable. Another failure mode associated with submersible power transmission cable is caused form impact loads or crushing of the cable as it is disposed or retrieved in the wells. It is also well known that gases found in subterranean environments impregnated the permeability of the electrical power transmission cable's insulation, wrapping and shields. This gas is trapped in the permeability of the insulation at a pressure similar to the pressure found inside the well. When the cable is retrieved from the well the electrically powered transmission cable is exposed to ambient pressures. This will create a pressure differential between gas encapsulated in the cable insulation and the

ambient surface pressure conditions. The rate of impregnated gas expansion from the higher pressure inside of the cable insulation expanding towards the lower pressure of the ambient conditions can sometimes exceed the cable insulation permeability's ability to equalize the pressure differential. The result is a void, or stressing of the insulation, and premature failure of the cable. The requirement to retrieve and dispose the electrical power transmission cable with the electrical submersible fluid traducer system also requires the use of specialized surface intervention equipment. This can require very large rigs, capable of pulling tubing, electrical power transmission cable, and electrical submersible fluid transducers. In the offshore environment these well intervention methods require semi-submersible drill ships and platforms. In the case of jointed conduit deployed in a plurality of threaded lengths, normally 9-12 m each, the pulling equipment is a drilling or pulling rig at surface. In the case that the electrical power transmission cable and assembly are disposed connected to or in continuous tubing, a specialized coiled tubing rig is required at surface. This coiled tubing unit consisting of an injector head, a hydraulic power unit, and a large diameter spooling device containing the continuous coiled tubing all located on the surface. This disposal and retrieval method requires significant space at the earth's surface or sea floor. The reasons for intervening in a well to retrieve or dispose an electrical submersible transducer system are well know to those familiar with the art of fluid removing fluids from wells. There are at least two classical reasons for intervention in wells disposed with electrical submersible fluid transducer systems. These

include the need to increase fluid production, or the need to repair the disposed electrical submersible power system. The reason for requiring increased fluid production is dependent on many factors including but not limited to economical and reservoir management techniques discussed in the literature. The reasons for intervening for repair or to replace the electrical submersible fluid transducer systems are due to normal equipment wear and the subsequent loss of fluid production capacity, catastrophic equipment failure, and changes in the fluid production capacity of the subterranean fluid reservoir. The equipment failures can be caused due to subterranean electrical failures in the electrical motor windings, electrical motor insulation degradation due to heat or mechanical wear, conductive fluid leaking into the motor, wear or failure of the fluid transducer parts, wear of electrical motor bearings, shaft vibrations, changes in inflow performance of the reservoir, and other phenomena known to those familiar with the art of fluid production from wells. Therefore, it is often required to change out component parts of the electrical submersible fluid transducer system, but not necessarily the electrical power transmission cable. However, owing to prior art the power cable is retrieved when the electrical motor or the motor seals fail. The current invention is an improvement to the known art of well construction, this invention teaches operational methods and claims apparatus related to disposing, operating, and retrieving electrical submersible fluid transducers systems. More particularly, the invention's methods and apparatus enables the electrical power transmission cable to remain in the well whilst teaching a plurality of

retrieving and/or disposing well interventions for components of the electrical submersible fluid transmission system.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 Shows a cross section of the well

FIG. 2 shows a cross section of a side pocket electrical wet connect device.

FIG. 3 shows a cross section of an expanding packer with three electrical feed throughs, unexpanded

FIG. 4 shows a cross section of an expanding packer with three electrical feed throughs, expanded

FIG. 5 shows a cross section of another embodiment of an expanding packer with feed throughs expanded

FIG. 6 shows an electrical feed through detail of figure 5.

FIG 7A shows a side view of a well with the completion installed and an electrically powered expanding tool adjacent to each expandable packer

FIG 7B shows a side view of the well with the two expandable packers expanded and the electrically powered roller expander being recovered back to surface.

FIG. 8A shows a side view of the well, with two expanded packers and a side pocket electrical connection.

FIG 8B shows a side view of the well, with two expanded packers and a side pocket electrical connection, with a docking support located at its lower end.

FIG 9 shows a side view of the well, with a pump being deployed inside the tubing and engaged and orientated into a locating profile built into the side pocket electrical connect

FIG. 10 shows a side view of the well, with a pump being deployed inside the tubing and the docking support both activating the conveyed electrical wet connect and providing the support for the entire weight of the deployed pumping device

FIG. 11 shows an isometric picture of the docking port as it is installed in the tubing.

FIG. 12 shows a side view of the side pocket wet connect

FIG. 13 shows a side view of the side pocket wet connect with the internally conveyed tool about to dock onto it.

FIG. 14 shows a side view of the side pocket wet connect with the internally conveyed tool dock onto it.

FIG. 14 shows a side view of the side pocket wet connect with the internally conveyed tool dock onto it and actuating the arbor with the electrical contacts on it

FIG. 15 shows a side view of the side pocket wet connect with the internally conveyed tool dock onto and connected to the side pocket annular wet connects.

DETAILED DESCRIPTION

Figure 1 Shows the casing of a well 1, in which a flush jointed tubing is installed 2 and externally strapped to the outside of the tubing is a power cable 3.

Figure 2 shows the cross section at the side pocket wet electrical wet connect. The electrical cable 3, if they are metal clad, are fed into guide tubes 4,5,6 , these both ensure the electrical wires follow a set path and are protected at this location. The guide tubes are part of the saddle 10 which holds the wet electrical connect assembly 7,8,9. The

saddle is a pressure vessel and internally, the wires are connected to the lower most end of the connectors 7,8,9.

Figure 3 to 6 shows an expanding packer with electrical feedthru's, The metal clad electrical cables 3 are installed inside tubes 20 in the eccentric wall 21 of the packer 22, the outer surface of the packer is coated in elastomer 23 for a pressure seal. When the inner surface 24 is expanded, it forces the rubber element into intermit contact with the casing 1. This is both a pressure tight seal and provides tensile capacity. The tubes 20 protect the electrical cables 3 from excessive compression forces. There are O rings around the cables 3 not shown. If the packer is some way along the tubing 2, it would be very difficult or impossible to feed the cables 3 through individual holes. In this situation slots 30 are machined into the packer body 31 so that the cables do not need to be cut but can be laid into the slot and held in place with suitable retaining means not shown. A protective cap 32 maybe used to prevent the metal clad cable being subjected to excessive compressive load when the packer body 31 is expanded. A small amount of elastomer or soft metal 33 may fill the void along the cable. When it is energized, it fills all the gaps and prevents fuilds and gases migrating along the cable.

Figures 7 to 10 show the well casing 1 with production tubing 2 and packers 22. A power cable 3 deployed on the outside of the tubing 2 and a side pocket wet connect 10. In one of the packers a vent check

valve 40 is located. Full bore access 50 to the well is possible for serving the perforations or sections of the reservoir.

During the initial tubing installation an electric motor 110 with roller expanding devices 111 located at packers 22. When set to the required depth, and hung off at surface, the electric motor 110 is energized from surface through the side pocket electrical connection 10, this is turn rotates the expandable rollers 111 which mechanically expand the metal packer 22 to come into intimate contact with the casing into its set position 23. Once this operation has been completed the electrically powered expander is recovered to surface using a slickline recover system (not shown) The docking support 41 in this instance would be left in the tubing. If however the tubing was left full bore, when it is required to deploy a device to be set at the side pocket electrical wet connect, a slick line deployed docking support 41 is lowered into the well and located at the required depth by a set of recesses 42 in the tubing 2. The pump assembly is then lowered into the well. It is orientated by a single 360degree groove cut into the tubing 2 (not shown) so that the assembly is orientated correctly to the side pocket 10. As it is lowered down the lower actuation arm 51 comes to rest on the docking rest 41, this is prevented from premature operation by a protecting shroud 52. The actuating arm operates an arbour 53 which hinges out the electrical connections on the lower end of the motor assembly 55 The electrical wet connection is made and completed 60 when the assembly comes to rest on the docking support 41. At the final rest position, it can be seen that the well fluids can

flow annularly 100 into the pump inlet 101 through slots 102 in the production tubing 2 When the pump is emergised fluid is discharged from the pump outlet 103 into the production tubing ID. If gas is separated from the pump, it needs to be separated to prevent the centrifugal pump from "gas locking" up. In this case a gas separator can be fitted, and its outlet can discharge into the chamber 110 this is vented into the tubing annulus via the check valve 40

Figure 11 to 16 show the side pocket electrical wet connect in more detail, A window is cut 71 in the tubing. Externally a saddle is made which holds wet electrical connects 70 and has metal tubes 4,5 and 6 which provide safe passage for the electrical cables past the window and allow the electrical connections to be made inside the saddle. The lower docking rest 41 is show located by a collet 73 in a recess 42. As the internally assembly is lowered down the actuating arm 51 comes to rest on the docking support 41 The top of the actuating arm 80 locates in a keyway 81 cut into the arbour 53, as the body is lowered down further the pin 80 follows the keyway 81 which causes the arbor to pivet about the pin axis 82 this deploys the arbour to the electrical connection position 90. As the toolstring in continued to be lowered by the amount 91, the electrical wet connections 92 are first engaged and finally fully engaged at position 93.

To disengage the reverse operation is performed.

Finally, figure 17 shows the recovery of the tubing in the event the well needs to be abandoned. The expanded sections could be machined out, or alternatively, if the body of the expanded section was titanium, an internal support tube 100 could be place into the tubing, then the titanium tube exposed to hydrofluoric acid, so that very rapidly the titanium tube dissolves and the tubing would be free to recover to surface.

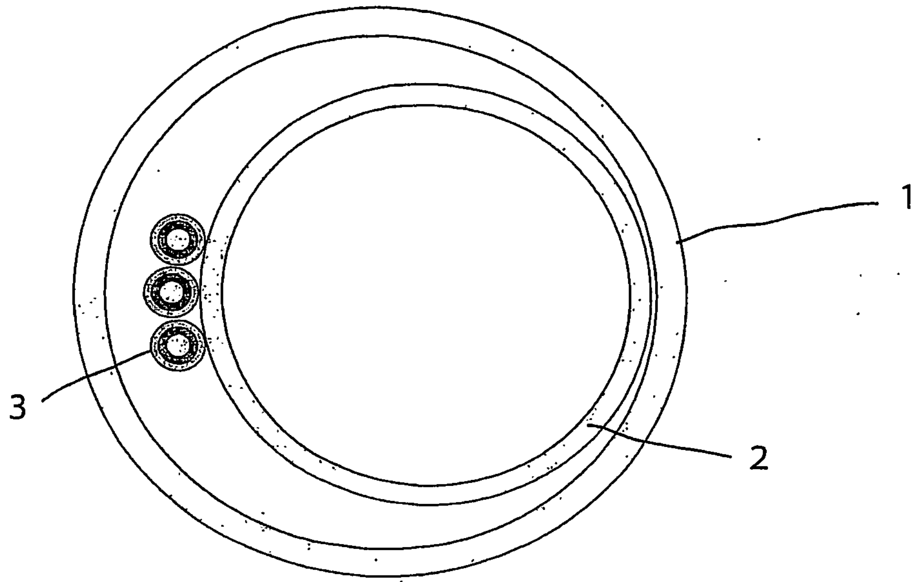


Figure 1

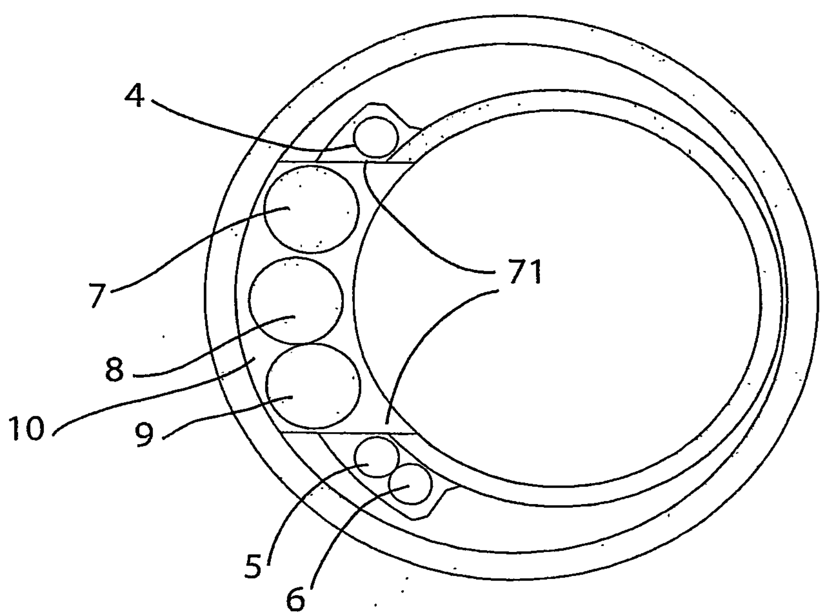


Figure 2

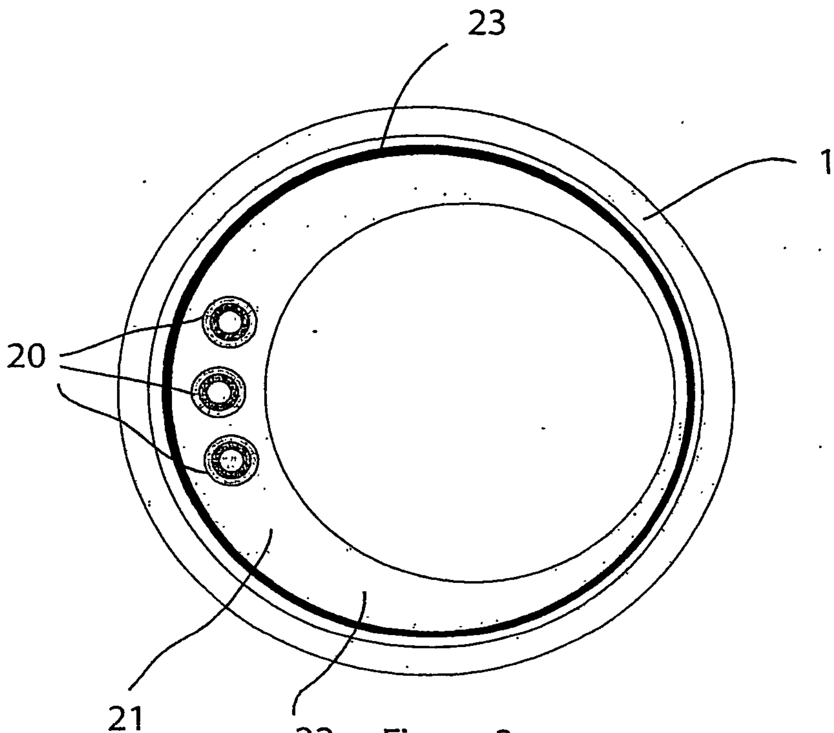
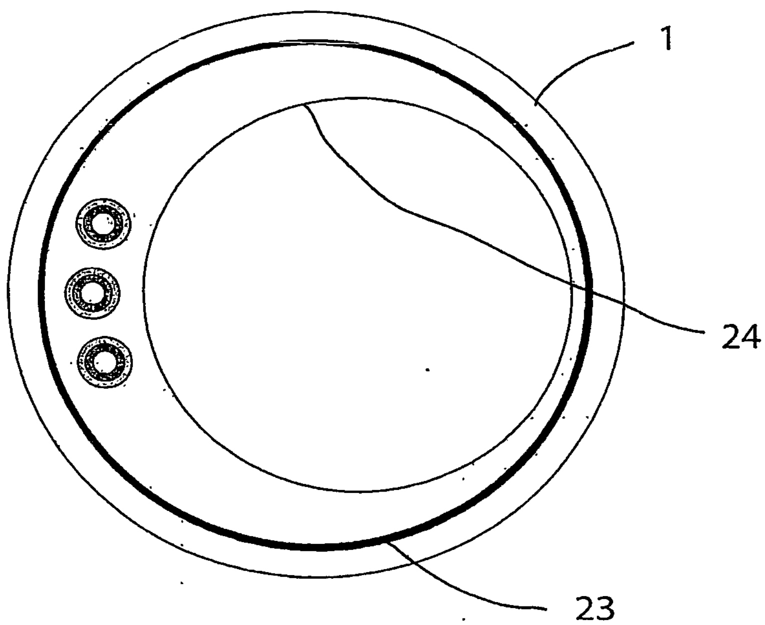


Figure 3



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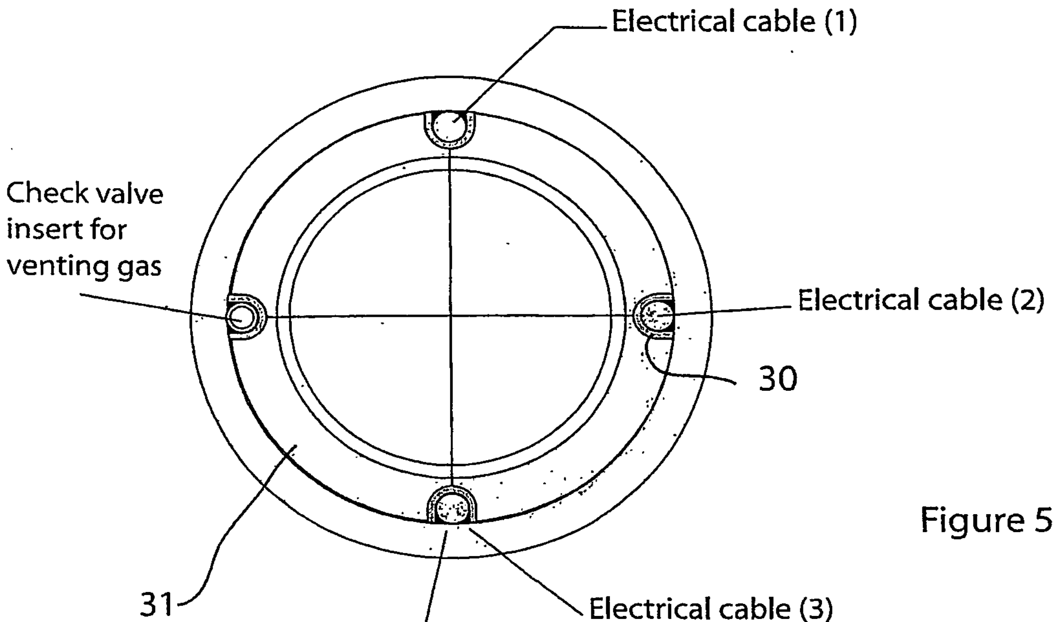


Figure 5

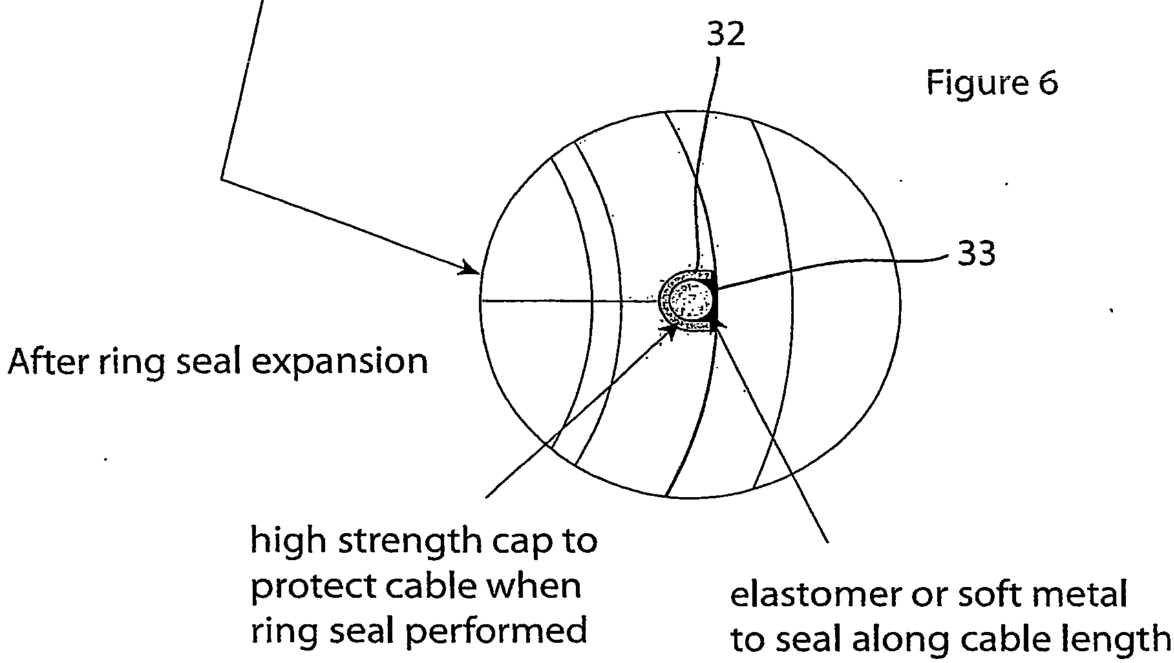


Figure 6

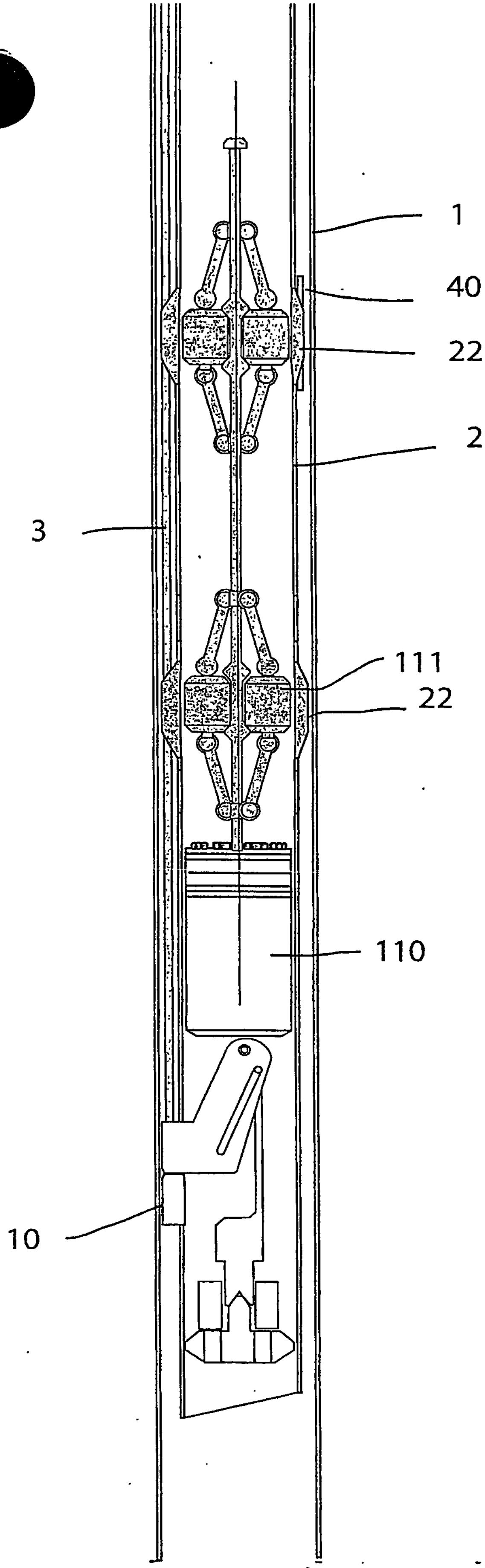


Figure 7A

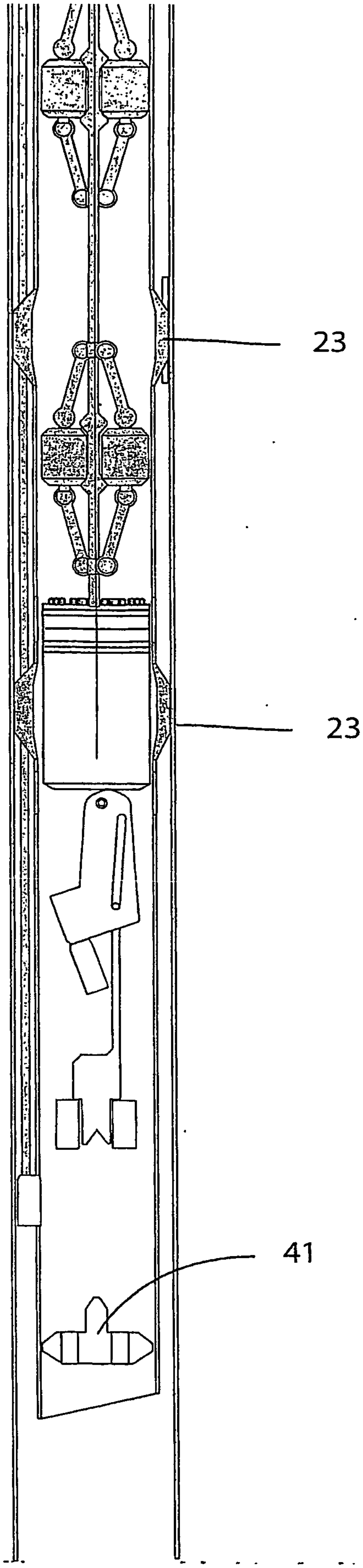


Figure 7B

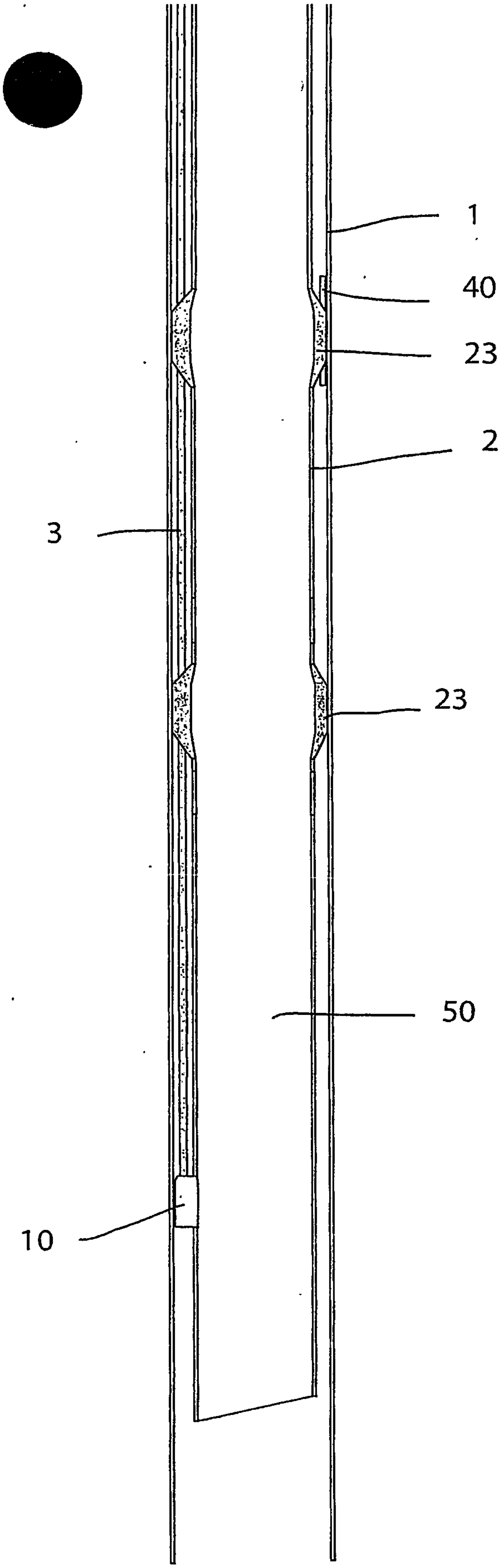


Figure 8a

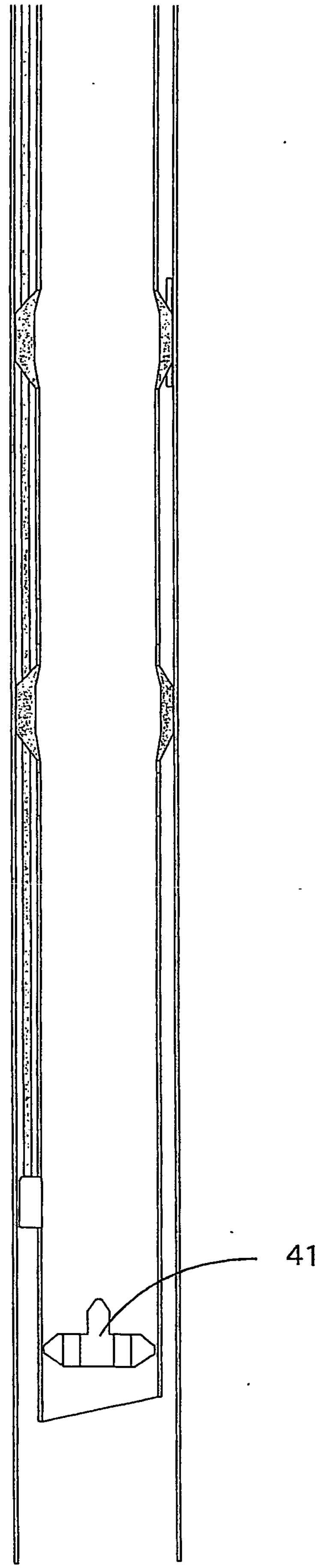


Figure 8b

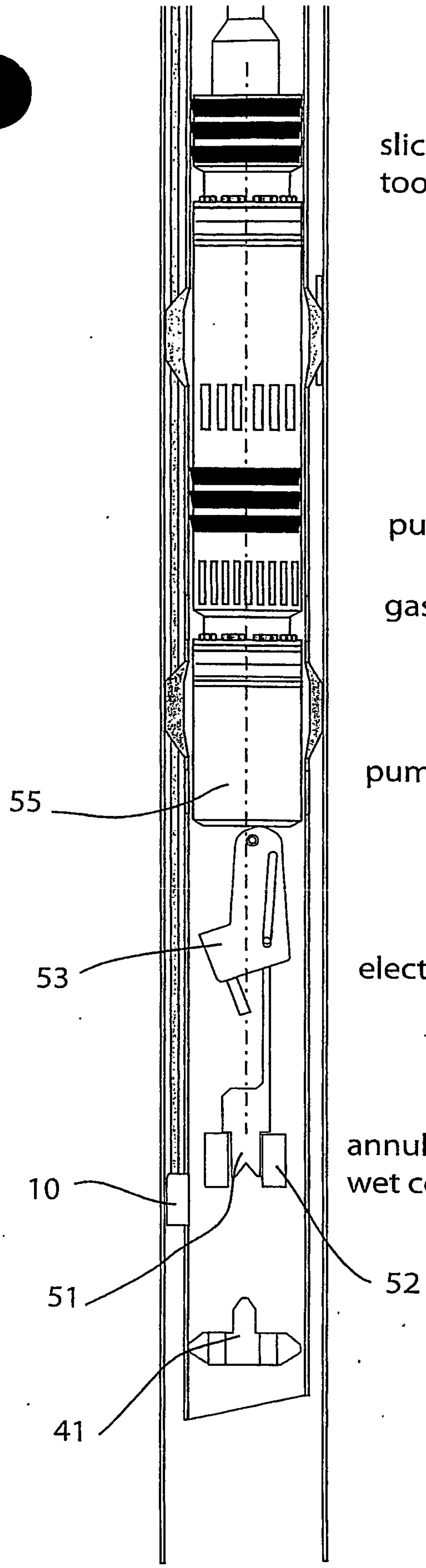


Figure 9

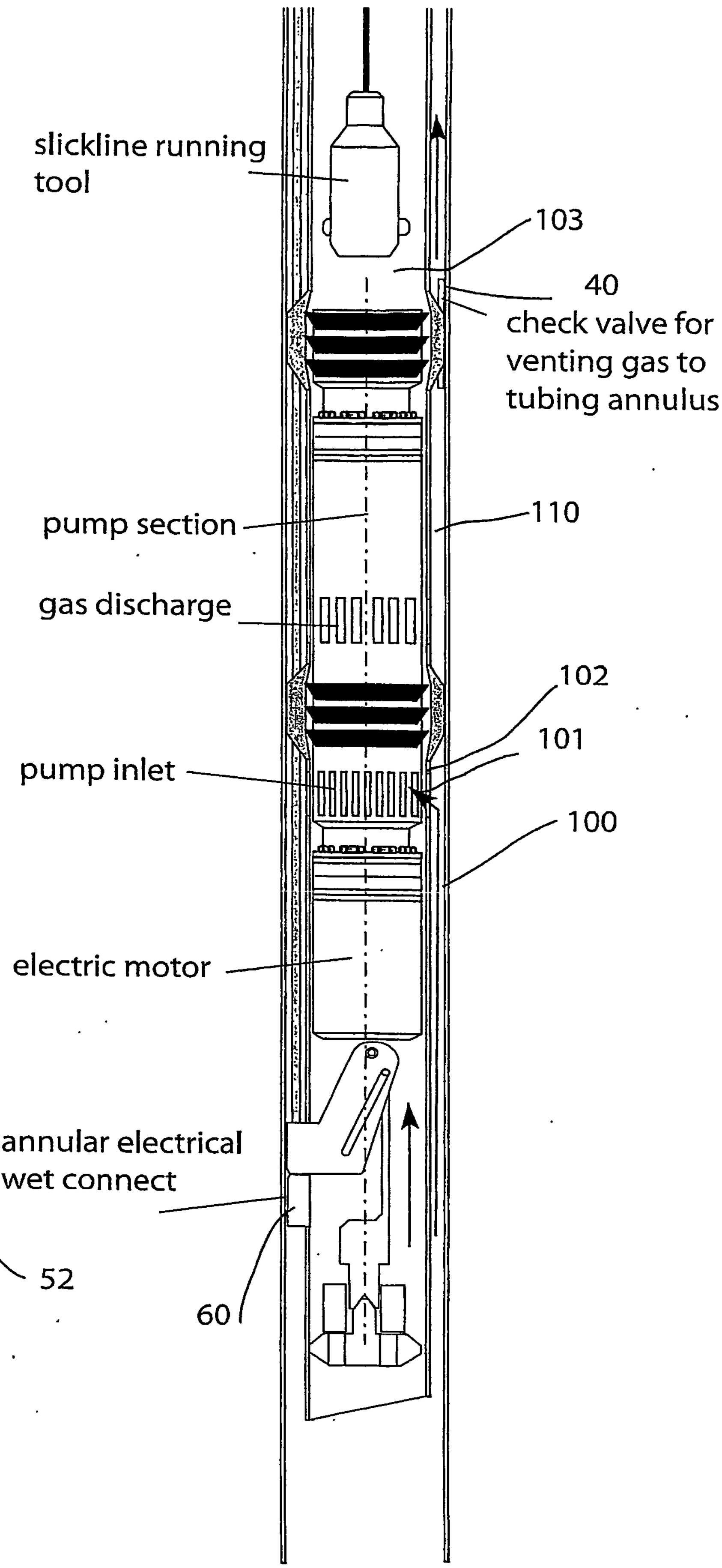


Figure 10

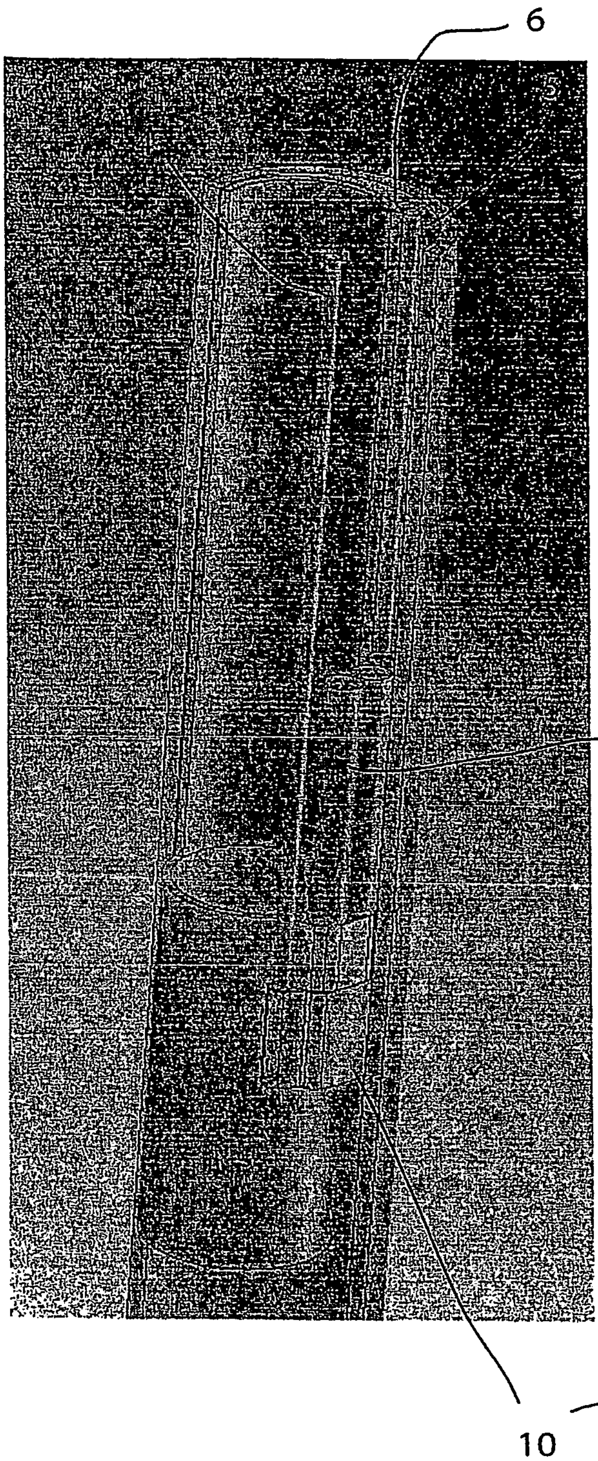


Figure 11

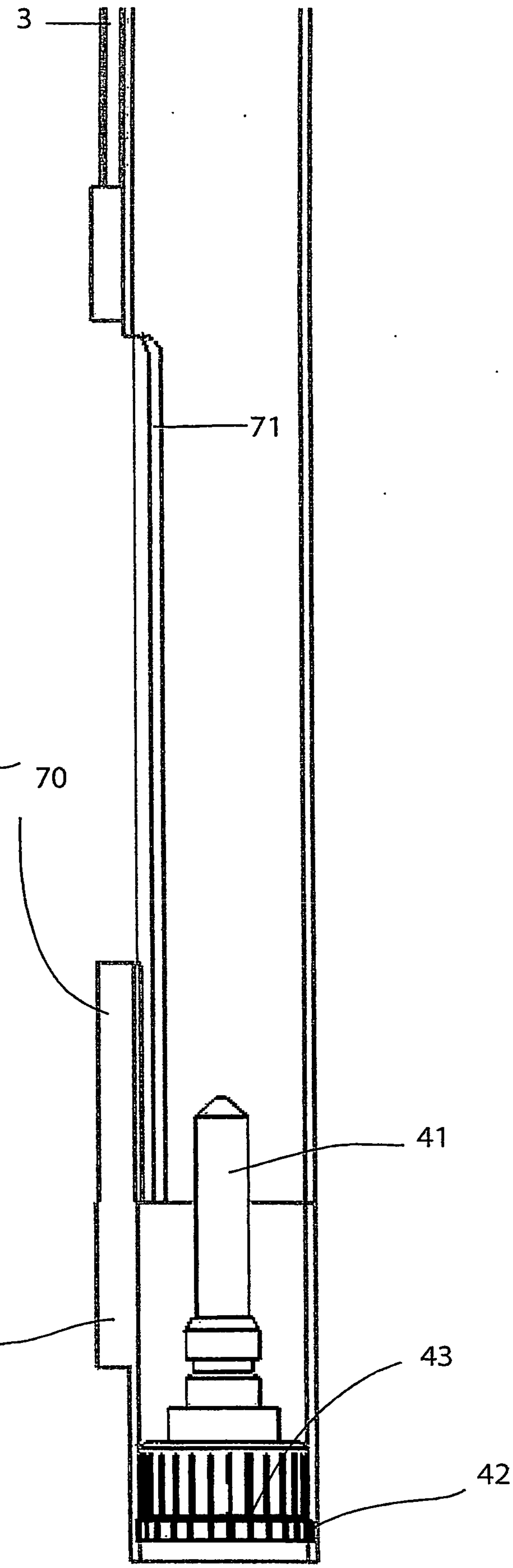
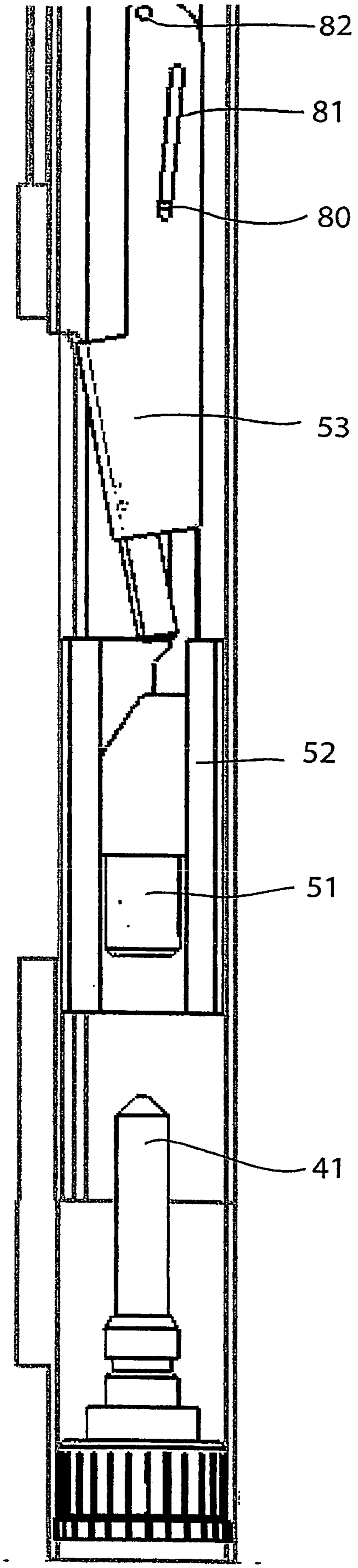


Figure 12



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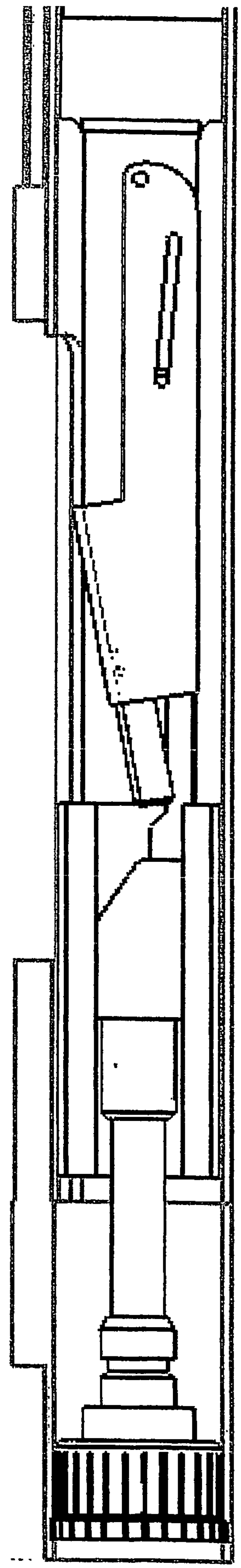

Figure 14

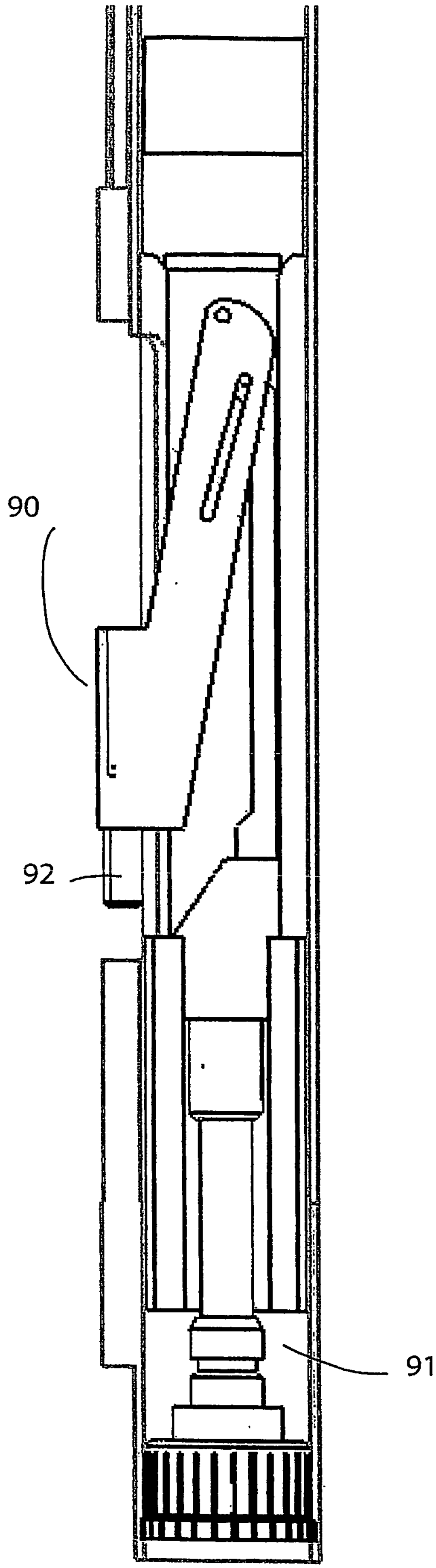

Figure 15

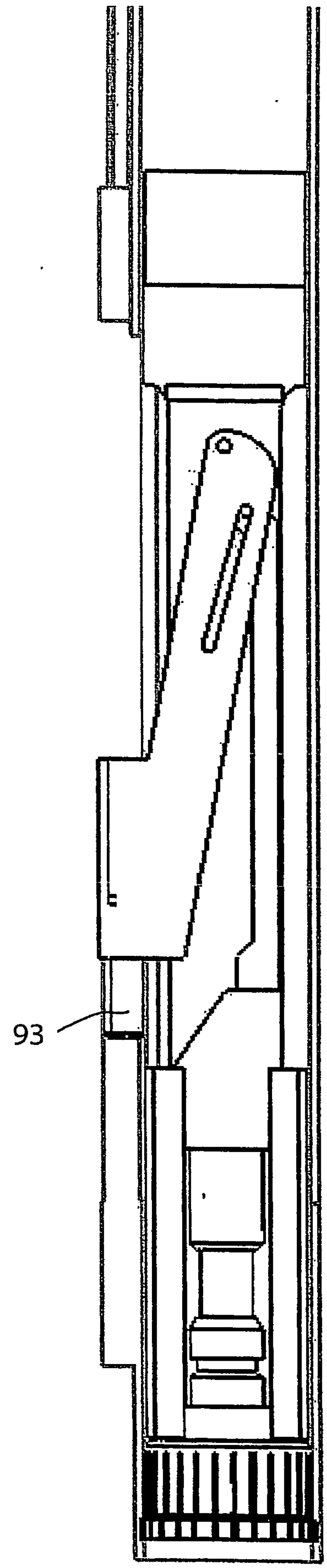

Figure 16

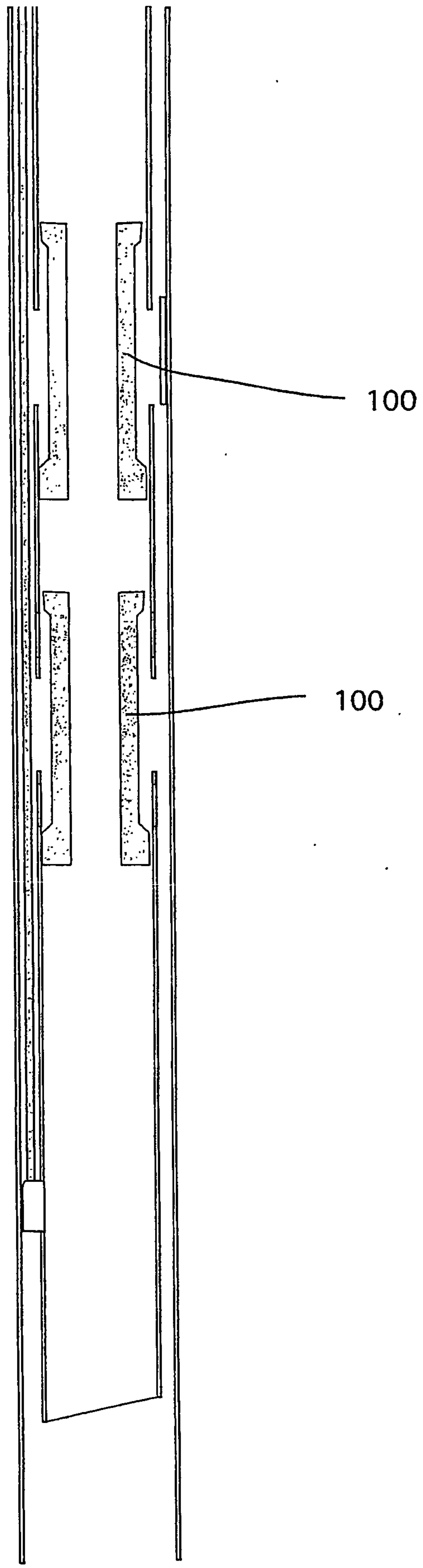

Figure 17

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